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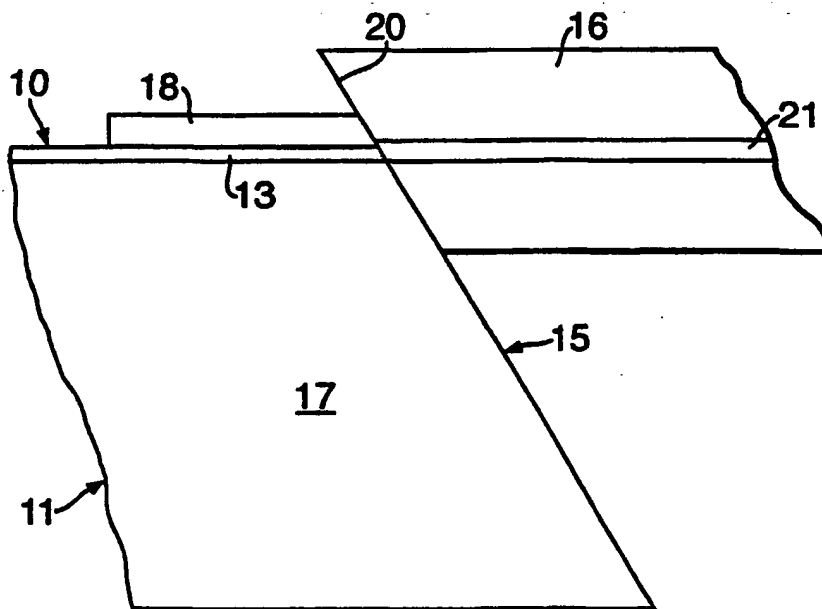
(43) International Publication Date
26 April 2001 (26.04.2001)

PCT

(10) International Publication Number
WO 01/29598 A1

- (51) International Patent Classification⁷: G02B 6/30
- (21) International Application Number: PCT/GB00/03936
- (22) International Filing Date: 12 October 2000 (12.10.2000)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
9924511.0 15 October 1999 (15.10.1999) GB
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- (81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ,
DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR,
HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,
LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ,
NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM,
TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG,
CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- Published:
— With international search report.
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: IMPROVEMENTS IN OR RELATING TO INTEGRATED CHIP OPTICAL DEVICES



(57) Abstract: A method of forming an integrated chip optical device as a protective layer formed over part of the face of the chip on which at least one optical waveguide is formed, and the protective coating is selectively removed leaving the coating over an edge region (18) and the edge of the device is polished to provide high edge quality against which offchip optical fibres may be abutted.

IMPROVEMENTS IN OR RELATING TO INTEGRATED CHIP OPTICAL DEVICES

The invention relates to integrated chip optical devices and is particularly related to such devices where optical components including at least one waveguide are formed on a substrate.

In order to make external optical connections to such an integrated chip optical device, it may be required to join off chip optical fibres to waveguides onchip adjacent an edge of the chip. To achieve satisfactory optical function at such a junction it is desirable that the chip has high edge quality where any such junction is to be formed.

It is an object of the present invention to provide an improved method of forming an integrated chip optical device as well as an improved device, having high edge quality for such external optical junctions.

The invention provides a method of forming an integrated chip optical device comprising forming a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, forming a protective layer over at least part of said surface including an edge region in which said edge is located, selectively removing the protective coating from certain regions of said surface while leaving the protective coating over said edge region, and polishing the edge of the device in said edge region to provide high edge quality enabling said waveguide to be abutted against and joined to an offchip optical fibre.

Preferably said protective coating comprises a hard setting photoresist.

Preferably said protective coating is spun over the surface of the chip.

Preferably the protective coating is selectively removed using

photolithography techniques.

Preferably a plurality of waveguides extend to said edge and each is secured to an offchip optical fibre.

Preferably each said waveguide is secured to an offchip fibre by adhesive with the fibre abutting the respective waveguide at said edge.

Preferably said edge is polished at an angle of inclination to the surface of the chip so as to reduce reflections at the edge passing along the waveguide or fibre.

In some embodiments said protective coating is removed from regions of the chip on which optical components are formed so as to leave said optical components uncovered by the protective layer.

The invention also provides an integrated chip optical device comprising a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, a protective layer being formed selectively over part of the surface of the chip adjacent an edge region in which said edge is located, said edge being polished to provide a high edge quality thereby forming a junction face at the edge of the chip for abutting said waveguide to an offchip optical fibre.

Preferably said edge is polished at an angle of inclination to the surface of the chip so that the external face of the waveguide is not perpendicular to the length of the waveguide.

Preferably one or more offchip optical fibres abut a respective waveguide at said edge and are secured thereto by adhesive.

An embodiment of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a schematic plan view of an integrated chip optical device in accordance with the present invention, and

Figure 2 shows on an enlarged scale a junction between one optical fibre and one waveguide in the device of Figure 1.

Figure 1 illustrates an integrated chip optical device such as a silicon chip waveguide device. Such a device may be formed on an integrated silicon substrate having a plurality of optical components formed integrally on the chip including a plurality of optical waveguides formed on the surface of the chip. In this example the chip is indicated at 11 and has a plurality of optical circuit devices 12 of known type. These optical devices may be connected by optical waveguides 13 to an edge region 14 extending along one edge 15 of the chip 11. The construction of the optical circuitry 12 and the waveguides 13 is of known type. In order to make external connections for the chip, the waveguides 13 each have an exposed end face adjacent the edge 15 and they abut respective optical fibres 16 at the edge 15.

In order to provide good optical operation it is required that the edge 15 has a high edge quality where the ends of the waveguides 13 abut end faces of the fibres 16.

To provide the high edge quality, the chip 11 has over its surface a spun-on coating of a hard setting photoresist after the optical circuitry 12 and waveguides 13 have been formed on the chip. The protective coating is patterned by photolithography so as to remove the protective coating from unwanted areas of the chip surface while leaving the protective coating along the edge region 14 up to the edge 15. In this way the protective coating only covers the edge region and the waveguide ends adjacent the edge 15. The optical circuitry 12 is now uncovered so that the

optical circuitry is not effected by any unwanted stresses that may be caused by leaving a protective coating over the optical components formed in the circuitry 12. After selective removal of the protective coating the edge 15 together with the protective coating in the edge region 14 is polished to give a high edge quality with high quality optical properties. This is illustrated in more detail in the enlarged view of Figure 2. In this Figure the chip 11 has a substrate 17 which may be silicon, with a waveguide 13 extending to the edge 15. The waveguide is covered by the protective coating 18 extending as a strip along the edge region 14. The edge 15 including the end of the waveguide 13 and the edge of the protective coating 18 are polished at an inclined angle relative to the surface and plane of the chip 11 so as to avoid the end face 15 being perpendicular to the plane of the chip. The optical fibre 16 has a similar inclined end face 20 and as illustrated in Figure 2, the core 21 of the optical fibre 16 is aligned in abutting contact with the end face of the waveguide 13. By use of an inclined face, there is reduction of any reflection at the junction being passed along the waveguide 13 or optical fibre 16.

Although Figure 2 illustrates only one optical fibre, it will be understood that optical fibres will be abutted against each of the waveguide outlets from the device shown in Figure 1 and each fibre will be secured by adhesive in abutting contact with the highly polished end face 15 in alignment with the respective waveguide 13.

The use of the protective coating 18 over the edge region 14 of the surface allows a high quality edge to be formed on the chip by polishing without damaging the structure of the waveguide where their ends reach the edge 15 of the chip.

References to the surface of the chip refer to the major face of the chip indicated at 10 in Figure 2.

The above example may be a silicon on insulator rib waveguide device.

The invention is not limited to the details of the foregoing example.

CLAIMS:

1. A method of forming an integrated chip optical device comprising forming a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, forming a protective layer over at least part of said surface including a surface region adjacent said edge, selectively removing the protective coating from certain areas of said surface while leaving the protective coating over said surface region adjacent said edge, and polishing the edge of the device adjacent the coating to provide high edge quality enabling said waveguide to be abutted against and joined to an offchip optical fibre.
2. A method according to claim 1 in which said protective coating comprises a hard setting photoresist.
3. A method according to claim 1 or claim 2 in which said protective coating is spun over the surface of the chip.
4. A method according to any one of the preceding claims in which the protective coating is selectively removed using photolithography techniques.
5. A method according to any one of the preceding claims in which a plurality of waveguides extend to said edge and each waveguide is secured to an offchip optical fibre.
6. A method according to claim 5 in which each said waveguide is secured to an offchip fibre by adhesive with the fibre abutting the respective waveguide at said edge.
7. A method according to any one of the preceding claims in which said edge is polished at an angle of inclination to the surface of the chip so as to reduce reflections at the edge passing along the waveguide or fibre.

8. A method according to any one of the preceding claims in which said protective coating is removed from regions of the chip on which certain optical components are formed so as to leave said certain optical components uncovered by the protective layer.

9. An integrated chip optical device comprising a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, a protective layer being formed selectively over part of the said surface of the chip adjacent an edge region in which said edge is located, said edge being polished to provide a high edge quality adjacent said protective layer thereby forming a junction face at the edge of the chip for abutting said waveguide to an offchip optical fibre.

10. An integrated chip optical device as claimed in claim 9 in which said edge is polished at an angle of inclination to the surface of the chip so that the external face of the waveguide is not perpendicular to the length of the waveguide.

11. An integrated chip optical device according to either of claims 9 or 10 in which one or more offchip optical fibres abut a respective waveguide at said edge and are secured thereto by adhesive.

12. An integrated chip optical device according to any one of claims 9 to 11 comprising a silicon on insulator rib waveguide device.

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Fig.1.

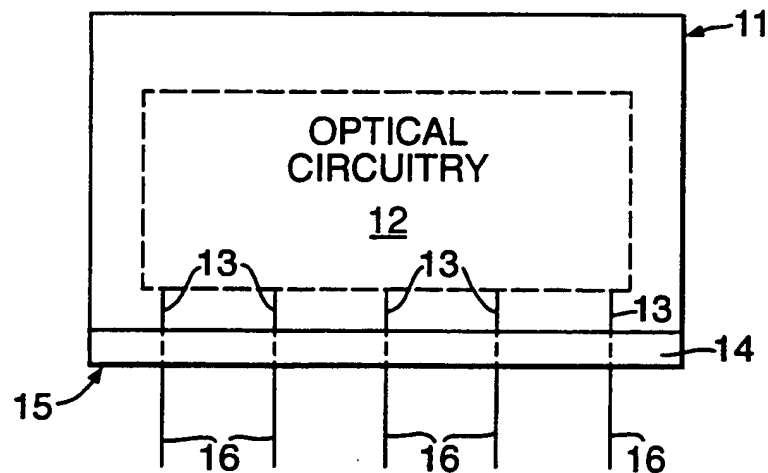
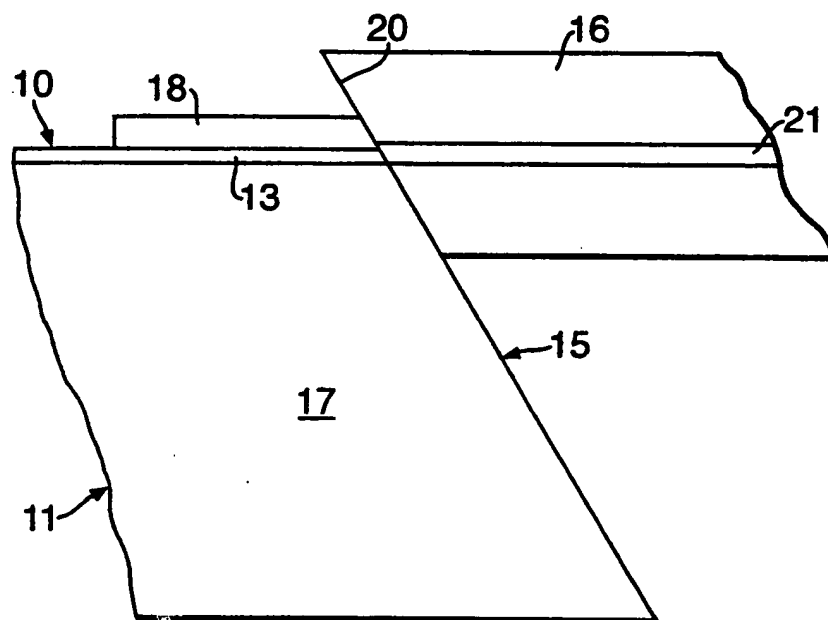


Fig.2.



INTERNATIONAL SEARCH REPORT

Inter. Appl. No.

PCT/GB 00/03936

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G02B6/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 766 930 A (SAMSUNG ELECTRONICS CO LTD) 5 February 1999 (1999-02-05)	1-6,9,11
Y	page 7, line 3 -page 8, line 10	7,8,10,12
	figures 1,4	
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 262 (P-1222), 3 July 1991 (1991-07-03) -& JP 03 084523 A (NEC CORP), 10 April 1991 (1991-04-10) abstract	9
	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

12 January 2001

Date of mailing of the international search report

22/01/2001

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INTERNATIONAL SEARCH REPORT

Inter. Appl. No.

PCT/GB 00/03936

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>DATABASE WPI Week 1991 Derwent Publications Ltd., London, GB; AN 151203 XP002156647 & JP 03 084523 A (NEC), 10 April 1991 (1991-04-10)</p>	9
Y	<p>abstract</p>	8
Y	<p>EP 0 652 451 A (CORNING INC) 10 May 1995 (1995-05-10) abstract column 4, line 50 -column 5, line 22 figures 1,3</p>	7,10
Y	<p>SCHUPPERT B ET AL: "INTEGRATED OPTICS IN SI AND SIGE-HETEROSTRUCTURES" PROCEEDINGS OF THE EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION (ECOC),DE,FRANKFURT, IGVDE, vol. CONF. 18, 27 September 1992 (1992-09-27), pages 793-800, XP000559168 ISBN: 3-8007-1897-9 chapter 'Pib-waveguides in Silicon-On-Insulator (SOI)'</p>	12

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. Appl. Application No

PCT/GB 00/03936

Pat nt docum nt cited in search report	Publication date	Patent family memb r(s)	Publication date
FR 2766930 A	05-02-1999	NONE	
JP 03084523 A	10-04-1991	NONE	
JP 3084523 A	10-04-1991	NONE	
EP 0652451 A	10-05-1995	AU 683088 B	30-10-1997
		AU 7756394 A	18-05-1995
		CA 2118087 A	09-05-1995
		JP 7181343 A	21-07-1995
		US 5526452 A	11-06-1996